RESEARCH REPORT NO. 24

A NAVY SHORE ACTIVITY MANPOWER PLANNING SYSTEM FOR CIVILIANS

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SHORE ACTIVITY MANPOWER PLANNING SYSTEM
FOR CIVILIANS

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INTRODUCTION

The human resources planning systems of the 1980s will be characterized as being oriented towards individualized use by both management and staff as part of a highly integrated management system. The Shore Activity Manpower Planning System (SAMPS) advanced development research project of the U. S. Navy has the objective of developing a prototype of such an integrated system. In this case, manpower models are to be tested in the evolving fourth generation computer capabilities provided by data communications networks and minicomputers. The SAMPS prototype is part of a coordinated Navy effort to bring together the various manpower and personnel modeling applications. An incremental approach is being undertaken so that usable products can be implemented as the project progresses.

The SAMPS project has been preceded by a long history of basic and exploratory development research. A discussion of the earlier phases of this research can be found in reports by Charnes, Cooper and Niehaus [7] and [8]. Also, a number of preliminary prototypes were developed as discussed in [2], [10], [18] and [20]. Support for these earlier application studies has been provided by the Chief of Naval Development in coordination with the Office of Naval Research. The SAMPS project is supported as part of the research programs of the Navy Personnel Research and Development Center (NPRDC).

One phase of the earlier modeling research found its applications in headquarters oriented civilian manpower planning. The algorithmic formulations can be found in [7]. These dynamic models use goal programming to meet a set of possibly conflicting manpower requirements "as closely as possible" for a number of periods in the future. This is done considering

various priorities and penalties for moving away from the requirements or goals. Also, constraints are set within which the requirements must be met. These may include: manpower already on-board; attrition, including retirements and internal transfers between job categories; total manpower controls; and total salary budgets. More extensive forms of the models include multi-level features to incorporate program planning directly in the models.

Another stream of the earlier research involved multi-attribute assignment models for man-job task analysis [11]. The ultimate goal of this research is the provision of the technology needed to accomplish dynamic organization design. This work is aimed at the objectives of providing tools to match individual people to individual jobs over more than one time period so that the resulting organization makes optimal use of the personnel available. This included reviewing the state-of-the-art of the use of occupational analysis for human resource development [17]. For the present, however, in SAMPS the applications are limited to static versions of these task analysis models. The algorithmic development and initial prototype development of the dynamic versions of these models remain a task in the exploratory development phases of the Navy's manpower research program.

An important aspect of manpower planning is the satisfaction of the needs for planning equal employment opportunities. An initial model for use in this area has been developed [6]. The preliminary operational forms of this model are already being used to assist in establishing the Navy's National Affirmative Action program. Such extensions are planned for incorporation in SAMPS. This development, however, will be a follow-on to

the initial models to be installed in the SAMPS computer support system.

Let us turn now to the systems concept of SAMPS, which is the basis for the initial computer support capabilities which will be exported to naval installations once they are tested.

System Concept

The near term goals of SAMPS are to provide the large naval shore activities with aggregate manpower modeling capabilities to assist in better manpower utilization. This includes the concomitant goals of providing better careers and equal employment opportunities for the employees. The longer term goals are to integrate dynamic organization design at the job element level with the aggregate planning process. Feasibility tests will also be conducted to examine how the SAMPS models and computer support systems can be integrated with other Navy systems for military manpower planning and for macro program planning. In this way, it should be possible for the Navy to develop a system responsive to both headquarters and local managers. 1/

Included in the research are to be prototypes to examine the relationships between SAMPS and the Shore Requirements, Standards and Manpower Planning System (SHORESTAMPS) under development by the Deputy Chief of Naval Operations (Manpower). SHORESTAMPS is primarily concerned with the development of civilian and military manpower requirements for the Navy shore establishments. This is done through the rigorous application of industrial

1/ See Sorensen and Willis [22] for a description of research aimed at relating changes in the shore establishment to changes in the fleet. Also, see Letsky [15] for a programmatic description of the Navy applied manpower research programs.

and management engineering techniques with particular emphasis on the use of staffing standards. SAMPS on the other hand is aimed at the evaluation of such requirements in relationship to the dynamics of the workforce. In the case of the aggregate models of SAMPS, this is done through the use of decision models using Markov transition rates embedded in a goal programming structure. Provision is being made in SAMPS to accept the manpower requirements data from the best source available, either from locally developed workload planning systems or from central planning systems such as SHORESTAMPS. The most important consideration to ensure the correspondence between SAMPS and SHORESTAMPS is consistent coding systems and methodologies to transmit requirements data from one system to the other.

The SAMPS advanced development research is being accomplished in three overlapping stages. The first step, which is underway, involves pilot testing of recruiting requirements models. This includes extending the conversational capabilities and embedding the model software in a data communications network. The second stage involves full-scale testing of multi-attribute assignment models for organization design and staffing studies. The third phase involves feasibility testing of the integration of the aggregate planning models and organization design models into one system.

The end product of SAMPS will be a system usable at the shore installation level as shown in Figure 1. The underlying objective of the system is the minimization of the difference between (a) organizational goals, (b) current manpower trends, and (c) employee aspirations. This would include the balancing of workload and policy planning at the aggregate level with individual assignments at the man-job level.

DYNAMIC ACTIVITY MANPOWER MODELING SYSTEM

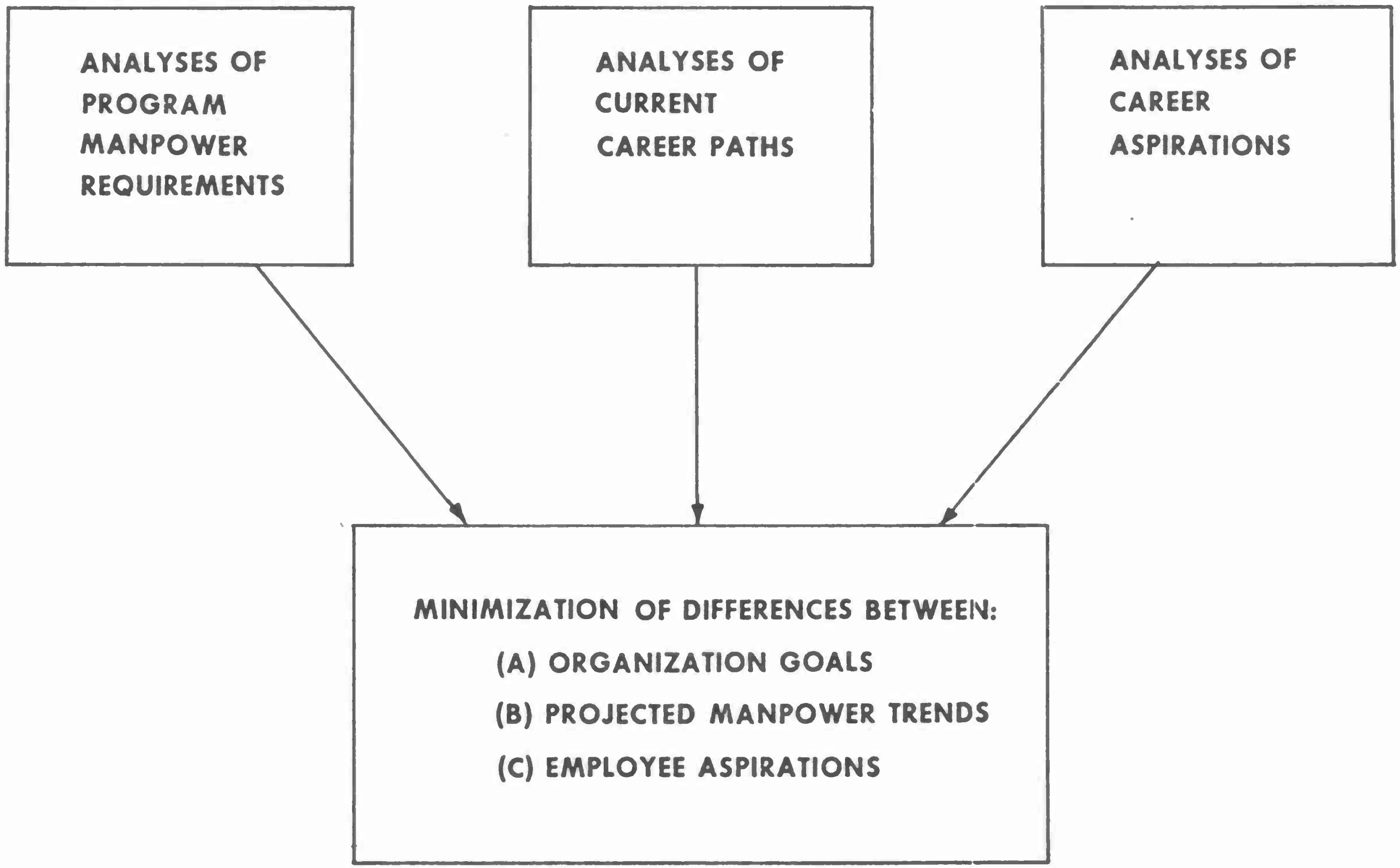


Figure 1

Extensions of the aggregate model include: (a) a multi-linked model to study interrelated parallel manpower systems such as major departments within a large shore activity, and (b) a multi-level model using input-output rates to integrate program planning directly with the manpower dynamics. Tests have been conducted on small numerical examples of multi-level, multi-linked models. Also, an example has been developed of a multi-level model for integrating military-civilian manpower planning at the macro level [9]. This latter model does not appear to be applicable at the local activity level.

The near term emphasis of the SAMPS project is on pilot studies underway at the Naval Air Rework Facility (NARF) San Diego and the Naval Underwater Systems Center (NUSC) at Newport, R. I. This is being done in parallel with the development of the software to test the models in a fourth generation computer environment.

The integrated workload and manpower planning model at the NARF [2] is being developed to meet some of the following needs:

1. Identification of manpower action requirements further into the future, expanding the detailed planning horizon.
2. Identification of longer term effects of proposed manpower actions.
3. Estimation of excess capacity within an expanded planning horizon.
4. Identification of areas where additional workload should be sought, in time for effective action.
5. Development of a capacity for rapid, detailed response to proposed workloads during the course of negotiations.
6. Development of the ability to evaluate alternative workload situations in detail.

The feasibility tests at NUSC Newport [10] are concerned with similar problems in the R&D environment. In these applications, the conversational form of the model is also being tested [20]. The preliminary tests have suggested a variety of changes in managerial support procedures, software and hardware configurations. Even without these changes, however, the conversational model appears to represent a vast improvement over previous support procedures. Further study is needed to extend the model into the program planning structures.

The software development is aimed at building a sufficiently advanced system so that the advantages of large scale data communications systems and intelligent terminals can be thoroughly tested. This will allow part of the input-output to be processed locally with the linear programs processed on the data communications network. The SAMPS software will be conversational in both input and output so that the main expertise for running the system will be knowledge of the underlying problem. The basic capability will be extended and augmented over time in order to provide still better requirements data on one hand and better assignment planning on the other. Additionally, advanced start techniques for solving the underlying linear programs will be incorporated to provide for larger problems or faster conversational turnaround or both.

A minicomputer is being procured to test interactive capabilities which provide both limited on-site computer support as well as the facilities of a large host computer in a data communications network. This minicomputer will have both CRT and printer capabilities with limited disk storage to store locally required data. The objective of the interactive tests is to find the lowest cost hardware arrangements to support large integrated

manpower models. This is of particular importance to the Navy since over fifty large shore installations may eventually be serviced by SAMPS.

The static multi-attribute assignment models are aimed at man-job matching. Initial tests using task analysis to obtain the individual job elements or characteristics have been conducted at the Naval Ship Research and Development Center [18]. In addition, a host of other uses of the assignment model is possible once the job element data base has been developed. Among these are included the ability to:

1. Aid in establishing training requirements by indicating the discrepancy between current capabilities of incumbents and position requirements.
2. Support a supervisory appraisal system by job element.
3. Assist in evaluating combinations of military and civilian assignments.
4. Aid in determining which people ought to be directed to what job as part of equal employment opportunity and upward mobility programs.
5. Provide registers of minimally qualified people for specific jobs as an aid in Merit Promotion procedures for promotion and selection.

In the intermediate and longer term stages of SAMPS, the research includes considerable emphasis on organization design and staffing considerations. Such applications will involve the integration of the aggregate models with versions of the static multi-attribute assignment models. Dynamic versions of these models will also be investigated in the later stages of the SAMPS project. Once sufficient modeling and computer support procedures

are in hand, attention will be given to using the model as a research vehicle for broader organizational sociological issues. Research of this nature will extend throughout the life of the project.

Aggregate Planning Models

The first major development task of SAMPS is the comprehensive feasibility testing of the aggregate planning models to be accomplished in a multi-phased effort. Parallel to the software development required is a continuing program of on-site activity-level model validation, which will permit immediate management information support for the test sites involved. Also, the working parts of the system can then be exported to other users at an earlier date. More importantly from a research standpoint, extensions to the models can be examined using a system that is already providing some results to the ultimate users. This should help to alleviate many of the normal user problems in the testing of these more complex systems. Thus, the early stages of development should both provide an initial set of users as well as function as the springboard for testing new ideas.

The first stage of the SAMPS development research is to broaden the application studies using the basic model at NARF, San Diego, and NUSC, Newport. In parallel with this research, operational studies are being accomplished using a headquarters-oriented computer support system. All of these operational applications are being supported by the software system called the Computer-Assisted Manpower Analyses System (CAMAS)[2]. The first stage SAMPS studies are being supported by a subset of the CAMAS computer programs. The usage of these programs, however, requires analysts familiar with computer software and is limited to a few sites which have access to the necessary UNIVAC 1108 computer hardware. These drawbacks gave rise to the SAMPS system design.

[2] See [19] for a description of CAMAS

The structure of the basic goal programming matrix[3] for the aggregate model is given in Figure 2. In this model the manpower requirements are set as goals to be met. A penalty is paid whenever the number of personnel on hand for a given category either exceeds or falls short of the manpower requirement. Relative penalties are also paid for adding to or reducing the work force. The fulfillment of the manpower requirements is then subjected to a number of constraints. First, the number on board in each job category at the start is set equal to the current population. This ensures that the base period population will be completely accounted for in the solutions. These base period populations are then submitted to a matrix of movement or transition rates which distinguishes probabilistically between those likely to stay in a particular job category, those likely to move to another job category, and those likely to leave the organization. This process continues for the number of periods to be included in the model. In addition, constraints are set for manpower ceilings and manpower salary budgets for each of the periods. Some of the possible extensions to this basic model are discussed in [6], [8], and [9].

The SAMPS advanced development research has a heavy computer support requirement. The software will first be written for a batch environment and then made fully interactive. In order to get started, versions of existing computer programs are being used. In this case the existing computer programs have been implemented on Navy computers to service the test sites only. A simple conversion of these programs to the data communications network is underway. This will provide some experience in the data communications environment prior to design of the more comprehensive capabilities required.

[3]See [7] for complete development of the model mathematics and transformations to the linear programming matrix.

Matrix Details for Civilian Manpower Goal Programming Models*

	POSITIVE GOAL DISCREP	NEGATIVE GOAL DISCREP	ON-BOARD MANPOWER	NEW HIRE MANPOWER	EXCESS MANPOWER	SIGN	RHS
RELATIVE PRIORITIES	β	β		γ	δ		
MANPOWER GOALS	-1 -1	1 1	1 1			= =	MANPOWER REQUIREMENTS
MANPOWER ATTRITION			1 -M 1 -M 1	 -1 -1	 1 1	= = =	INITIAL POP 0 0
TOTAL MANPOWER CONSTRAINTS			1111 1111			$\leq$ $\leq$	CIVILIAN MANPOWER AVAILABLE
SALARY BUDGET CONSTRAINTS			(\$/m)1 (\$/m)2			$\leq$ $\leq$	CIVILIAN SALARY BUDGET

*Source: *Figure 3 in* (7) *p. I - 13.*

Figure 2

The basic computer support for SAMPS may be divided into two parts[4]:

1) A headquarters controlled system of programs to be run at the central UNIVAC 1108 site supporting OCMM, using the complete Navy civilian personnel data base.

2) A field installation controlled set of programs which restricts access to only the installation's own data base.

The headquarters part of the SAMPS system is designed to ensure standardization and maintain some central control, while minimizing the use of central staff resources in servicing the field use of the manpower models. All of the files with the exception of the transition matrices are designed to be able to be developed locally. The headquarters part uses a UNIVAC 1108 batch system for the quarterly production of all desired transition matrix files for each of the field installations that is part of the system.

The greatest change from the current CAMAS support system is the use of separate files for each of the periods used in developing the transition matrices. In CAMAS a combined two-period file is first created separately for white collar and blue collar employees prior to developing the transition matrix. The SAMPS Personnel Master file, however, will include both the white collar and blue collar employees on the same file. This will permit a simplified approach to the running of models which must include the total manpower resources of a field installation.

[4]The development of the SAMPS computer support system is being accomplished by the Naval Command System Support Activity (NAVCOSSACT) under the leadership of C. Aub and N. Cooper.

The use of separate Personnel Master files for each quarter has many advantages. It means fewer files to be prepared and stored, as multiple two-period files for different combinations will no longer be created. It will eliminate the perennial problem of differing numbers of on-board personnel for the end points of combinations of periods involved. Also, it makes it possible to limit the quarterly files, which contain over 300,000 records each, to a single reel, even though they will now contain both white collar and blue collar employee records.

A new extract program is being written which will permit the field installation to access only the data applicable to its own population. The necessary protect keys and passwords will be employed. Also, the field installation will be limited in its access to the employees' names and file numbers to ensure conformance with the Federal Privacy Act of 1974.

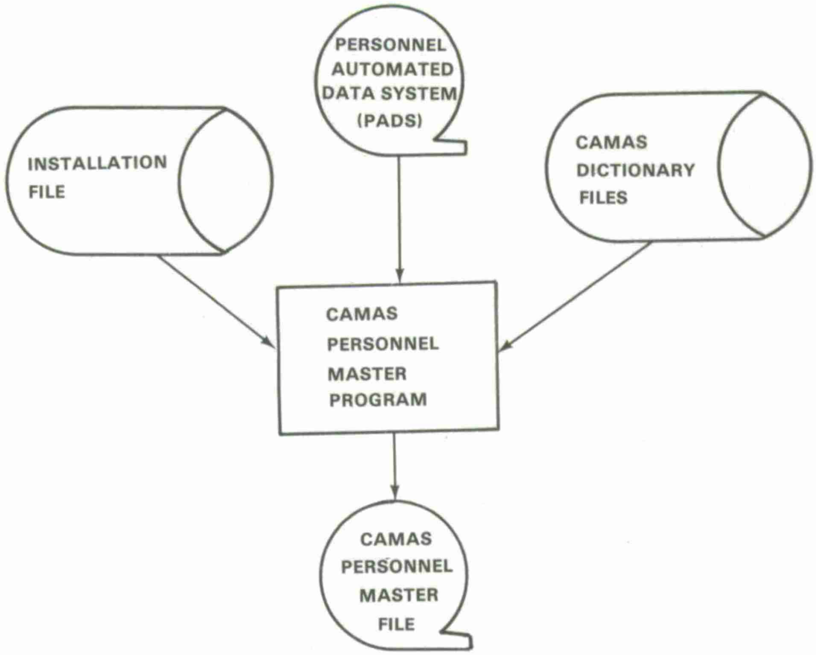
The field installation part of SAMPS will consist of a conversational system usable by managers with no knowledge of programming or computer executive systems. This software will be capable of guiding the user through the preparation of the principal input file to the linear programming package, allow him to start a runstream to run the linear program, and then conversationally access the results, make changes, and rerun if desired, finally being able to start a runstream to print out the solution reports. Such a capability represents a substantial extension and modification to the output-oriented conversational system (CURRM) reported in [20]. The revised SAMPS addresses the creation of the linear programming input, which is assumed given in the CURRM system. The SAMPS also makes provision for storing and recalling various versions of the files involved in a data communications environment and includes an accounting system to monitor and record frequency and volume of use of the individual programs.

A generalized flow diagram of the aggregate planning model portion of SAMPS is given in Figures 3 through 5. In Figure 3, the flows of the personnel master and projected salary subsystems are shown. The data base includes: (1) the individual employee records contained in the Personnel Automated Data System (PADS), (2) a file of organizational unit records to provide the budgetary and location codes for each of the shore installations, and (3) a dictionary of codes and names to describe and name the job categories used in the planning system. These data are brought together to create a CAMAS personnel master file of individual employee records containing only the data pertinent to manpower planning.

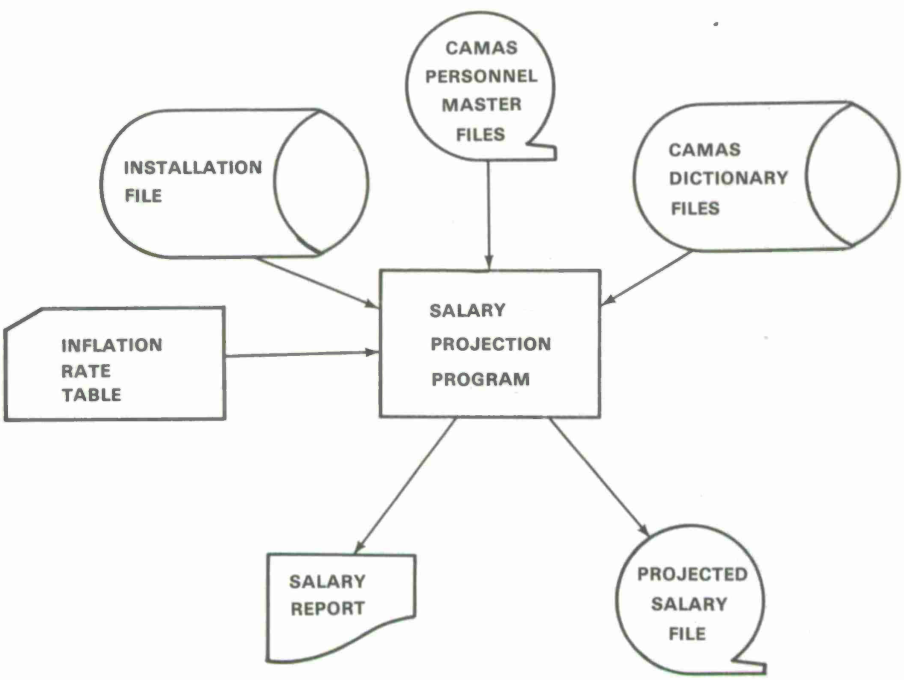
The projected salary subsystem provides average salary by each of the job categories for each period used in the aggregate model. The data base includes the CAMAS Personnel Master file, the installation file, and CAMAS dictionaries. A card file is also included to indicate the projected rate of inflation in each of the planning periods.

Figure 4 is a flow diagram of the subsystem which furnish the projected transition matrices used in the models. Included are several programs to modify the transition rates to account for projected retirements. The heart of this process is the transition rate program which calculates the necessary personnel movements data by comparing CAMAS personnel masters for two different periods. Control cards are used to indicate the job categories and other specific constraints to be used in developing the rates. Extract programs which are not shown may also be used to delimit the incoming files prior to processing. Outputs include transition matrices on those eligible to retire and on the base population of those not eligible to retire. Also, reports can be produced to display the transition rates for analysis of historical trend statistics. These reports are useful in their own right, particularly as far

SHORE ACTIVITY MANPOWER PLANNING SYSTEM (SAMPS)
HEADQUARTERS SUBSYSTEMS



PERSONNEL MASTER SUBSYSTEM

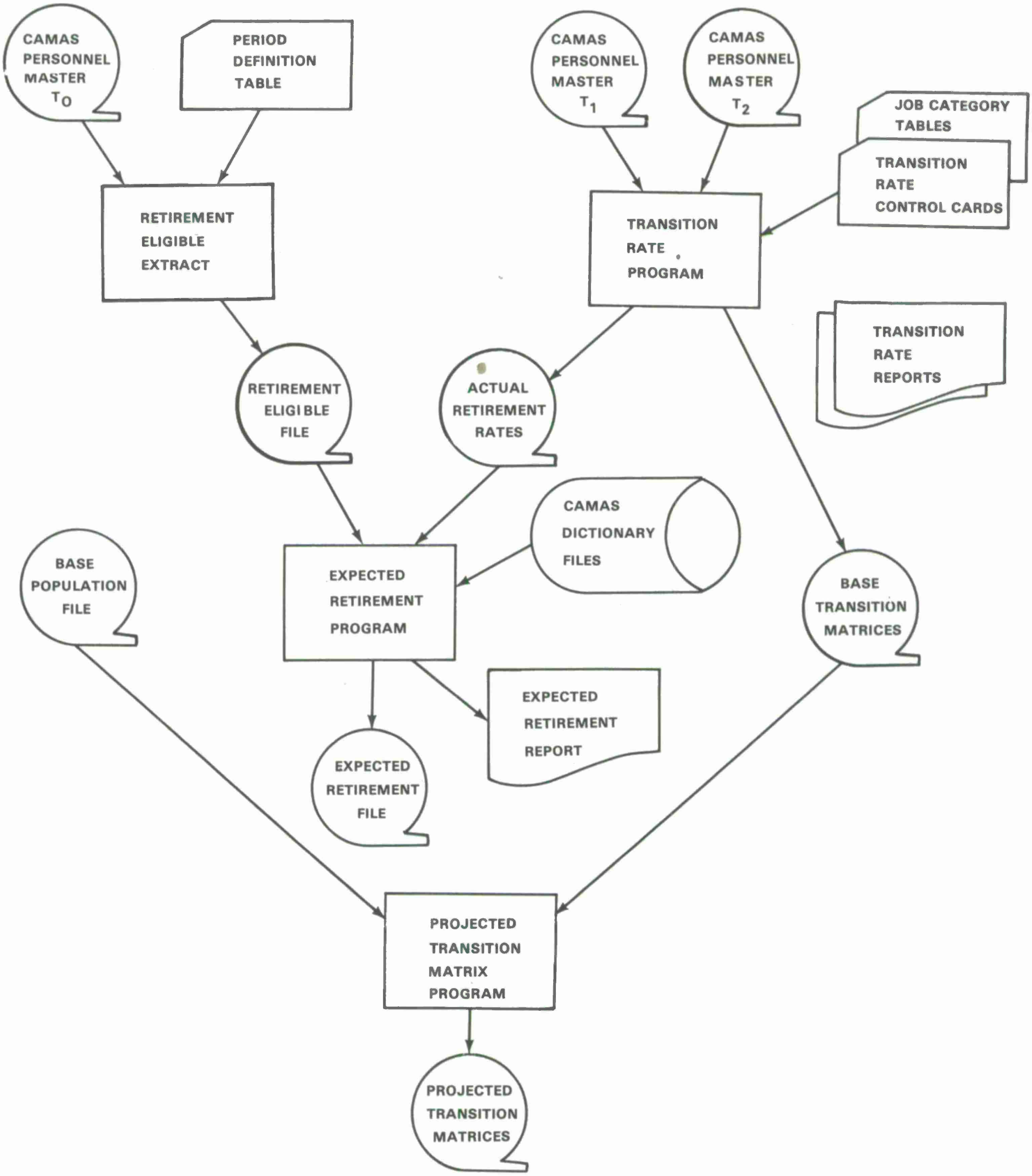


PROJECTED SALARY SUBSYSTEM

FIGURE 3

SHORE ACTIVITY MANPOWER PLANNING SYSTEM (SAMPS)

HEADQUARTERS SUBSYSTEMS



RETIREMENT AND TRANSITION RATE SUBSYSTEMS

FIGURE 4

SHORE ACTIVITY MANPOWER PLANNING SYSTEM (SAMPS) FIELD INSTALLATION SUBSYSTEM

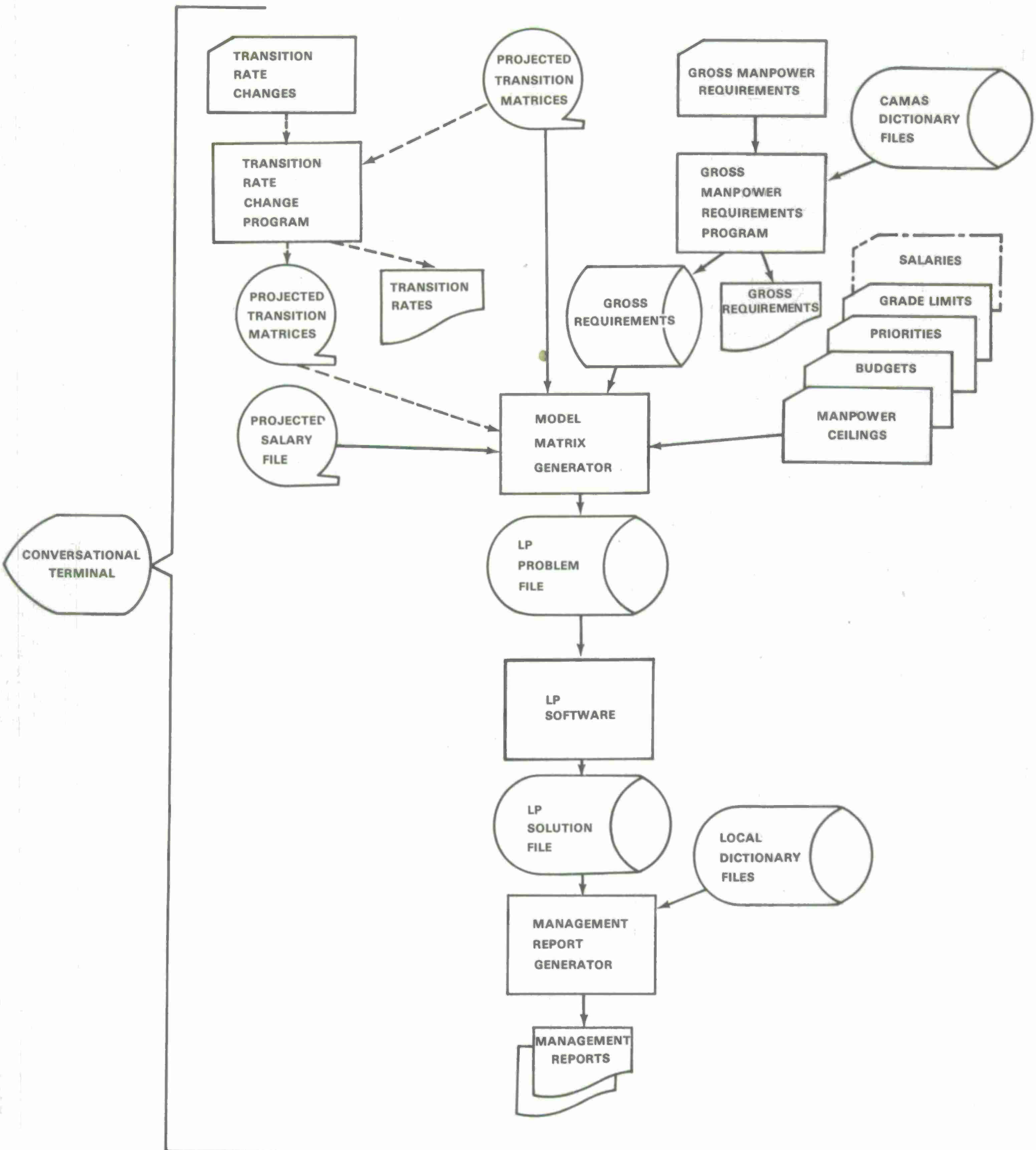


FIGURE 5

as the attrition rates are concerned. They have also proved useful where the population under consideration is too small to produce more comprehensive projections using the aggregate model.

Also obtained from the CAMAS personnel master are extracts of: (1) those who will be eligible to retire at some time during the planning period used in the model and (2) the base population, or those who will not be eligible to retire. The retirement eligible file is then used with the retirement rates to project the expected retirements for each of the periods. A report can also be produced showing these data using the CAMAS dictionary titles to translate the encoded data. The base population file and the expected retirement file are then used to adjust the base transition matrix to obtain the projected transition matrices required.

The flow diagram to assemble the model, solve it using linear programming software, and display the results is shown in Figure 5. This subsystem is accessible by field installations via the data communications network. Eventually, it will also be made completely conversational. The model matrix generator assembles the data required to use the linear programming software. Various combinations of models are to be possible, with a minimum version restricted to evaluation of manpower dynamics constrained by manpower ceilings. The projected transition matrices can be modified if desired. They also can be printed. The gross manpower requirements can be read into the model by means of a card file. In most cases, however, these data would be obtained from a workload projection system applicable to the type of installation involved. The projected salary data can be read either as created by the salary subsystem or as card input. Data on manpower ceilings, total salary budget, priority weights, and grade limits are to be provided as card data.

The output from the model matrix generator is the linear programming problem file. This is read into the linear programming software and the results obtained. The linear programming solution file along with a dictionary of job category names and comment cards specific to a particular model are then used to display the results. In the conversational mode output may be restricted to displays on the terminal until a desired solution is obtained.

The tests of the aggregate model at NARF, San Diego, are a continuation of exploratory studies by Bres and Niehaus [2] which indicated the possible usefulness of the models. Currently, these tests are being conducted in the Workload Coordination Section of the Production Department[5]. The initial model results were obtained using the CAMAS software on a computer in Washington with the output provided periodically to the NARF. Considerable effort has been expended to transfer this software to a UNIVAC 1110 computer in San Diego. The NARF computerized workload planning system is also being changed to provide the manpower requirements data directly to the model. In addition, modifications to the software were made to allow interactive use by a skilled computer specialist. The solution reports were also reduced from 132 columns to 80 columns to permit transmission to a thermal printer.

Recent results from the use of the model are shown in Figures 6 and 7. Figure 6 is a summary report showing the projected skills distribution for four quarters into the future. These are the ABO (aboard) figures. Also shown are the hiring (HIR) and reductions in force (RIF) necessary to obtain the projected skill distributions. Figure 7 is a more detailed report produced for each planning period. It shows the relationship of the projected skill distribution aboard in relationship to the manpower requirements as generated by the NARF workload

[5]These tests are being accomplished through the assistance of R. Grandmaison, B. Gallant, and R. Williams.

NARF SAN DIEGO MODEL - RUN 3

CATEGORY	ABO DEC 75	MAR 76 ABO	MAR 76 HIR	MAR 76 RIF	JUN 76 ABO	JUN 76 HIR	JUN 76 RIF	SEP 76 ABO	SEP 76 HIR	SEP 76 RIF	DEC 76 ABO	DEC 76 HIR	DEC 76 RIF
INST ELEC	39	44		1	41		7	39			39		
ELEC MECH	337	335	19		323			311		15	304		
AIME	43	35		7	34		4	35	1		35		
A/C ELECT	529	542	29		523			498		9	488		
MACHINISTS	296	293			289		1	271		10	264		
TOOLMAKER	19	19			19			19			20		
BUFF/POLSH	11	12		1	11			11	1		12		
WELDER	28	22											
ELECTROPLT	114	111											
MTL PROC W	18	18											
SHT MTL ME	759												
OXY EQT ME	F												
A/C ENG ME	?												
A/C OVL ME													

Figure 6

NARF SAN DIEGO MODEL - RUN 3
MANPOWER REPORT FOR MAR 76

CATEGORY	ABOARD	HIRES	RIFS	GOAL	DISCREP	LIMITS	
INST ELEC	44		1	39	5	34	44
ELEC MECH	335	19		335		295	375
AIME	35		7	35		31	39
A/C ELECT	542	29		542		477	607
MACHINISTS	293			303	-10	267	339
TOOLMAKER	19			19		17	21
BUFF/POLSHR	12						
WELDER	22						
ELECTROPLTR	111						
MTL PROC WKR							
SHT MTL MECH							
OVL EQT MECH							
A/C ENG MECH							
A/C OXY MECH							

Figure 7

planning system. For example, in the March 1976 quarter, it was projected that the NARF should plan for 293 machinists, which is ten below the 303 required in that quarter to accomplish the workload planned. The difference should be made up using overtime or some other means. The reason for this is that the demand for machinists is projected to be significantly lower in future planning periods (for Dec 1976 the requirement for machinists has dropped to 264).

The NARF study is now providing data which are timely enough to be used in parallel with the present planning practices. This is being done in a retrenchment environment where substantial changes are required in both the number of personnel and the types of skills required. It is worth noting that the model results developed in December 1975 indicated that there should be a reduction-in-force of 92 people by end of June 1976. This is very close to the actual reduction of 93 people requested, approved and recently made public by the Department of Defense. These tests of the model are providing types of data which are not available in the manual system. Also, the model results extend farther into the future than the manual system and can be generated in a more expeditious manner. Preliminary discussions are underway with NARF personnel to extend the research studies so as to include more of the internal interrelationships within the NARF.

A considerable amount of work has been accomplished by Niehaus, Sholtz, and Thompson [20] in developing a conversational capability (CURRM) on the UNIVAC 1108 computer. This capability has been tested by the management of the Naval Underwater Systems Center, Newport[5]. The test addressed the problem of determining the number of junior professionals to be hired over the next three years, in light of very restrictive ceiling and high grade constraints. The

[5] These tests are being conducted with the assistance of R. Albanese and K. Padalino at NUSC. See [10] for a description of the initial work at NUSC.

numbers of junior professionals to be hired are integrally related to promotion policies and thus to the total staffing picture. The output from this model study was used to assist in planning for a recent major reorganization.

A listing of the commands used in the first CURRM tests is shown in Figure 8. The initial test indicated that it was highly desirable to provide the ability to alter several data values simultaneously rather than one at a time, or even by means of the available parametric capabilities such as changing all the manpower requirements in a particular period by a percentage. Without the ability to alter several data values simultaneously, the CURRM version of the model does not provide a significant advantage over the batch version of the model. The more critical modifications to CURRM to correct this deficiency are being completed by the Naval Command Systems Support Activity (NAVCOSSACT).

Other modifications which appear desirable fall into two groups: those that assist the operator or analyst in his job and those that render the management reports more comprehensible. Most of the latter involve improving the quality of the reports by additional decoding of the model variables and removing minor and apparent inconsistencies between the terminal and hard copy outputs. Without the removal of these rough edges, it is felt that a non-computer oriented person might be apt to think that something was "wrong" and that therefore the output was not to be trusted. In this light, such changes take on additional importance.

An examination has also been made of ways to improve the solution times of the underlying linear programs used to solve the models. This examination has included both a formal mathematical approach and an experimental approach. The formal approaches by Charnes, Cooper, Klingman, and Niehaus [4], [5] indicated that the advanced start and explicit solution techniques studied apply

CURRM COMMANDS

GENERAL

RUN	R
STOP	E
OCC. CODES	POC
HELP	HELP

DISPLAY

SOLUTION REPORT	PS
HIRES	PH
RIFS	PR
ABOVE GOALS	PA
BELOW GOALS	PB
ITEM	PI

CHANGE

GOAL	G
GOALS BY %	GP
CEILING	C
BUDGET	B
LOWER BOUND	L
UPPER BOUND	U
PENALITIES	P
TRANSITION RATES	T
SALARY	S
SALARY BY %	SP

PRINT(OFF-LINE)

SUMMARY MANPOWER REPORT	LP1
DETAILED MANPOWER REPORT	LP2

Figure 8

to the general class of convex goal programming problems rather than being limited to manpower planning. The experimental work of Korn [13] is based on the assumption that the solution to most problems would be at or near the goals. Thus, the starting basis is set at the goals. For small problems of 600-800 equations this basis reduced the solution times by 50% on a UNIVAC 1108 computer using the FMPS linear programming software. For larger problems of 3000 equations, the solution time was reduced by a factor of 10, from several hours to 10-12 minutes. Using modern linear programming codes this solution time was reduced to 2-3 minutes for the larger problems and 8-15 seconds for the smaller problems. It was learned that even better solution times can be obtained if the advanced start is used on the dual form. The model matrix generators to be included in the later version of the SAMPS software will take advantage of this research into advanced start methodologies.

The advanced start studies show that the solution of the linear programs for the size of problems to be expected at shore installations is within the realm of the conversational on-line use of the model at a relatively small cost ($10-$15 per model alternative). With this information on hand, it is clear that the costs of using the model are more a function of the staff man-hours involved rather than the computer costs. Intensive participation of an analyst is required during the model generation and analysis of alternatives phases. Also, initial startup to use the model requires greater than average staff participation. Study of these cost and staffing dimensions is included in the continuing SAMPS research program.

The tests have already indicated that the hardware configuration is of importance. There is a need to see a record of the transactions if one is in the conversational mode and to have the full output reports accessible to the user during the interactive session, although the demand for output printing

capabilities at the conversational site does not appear to be extensive. It is strongly recommended, however, that the minimum configuration include a teleprinter running at 1200 baud. Even more desirable would be a minicomputer with both a CRT and a printer. Testing is to be included as part of the SAMPS research to see what is the best on-site hardware-data communications configuration, including an investigation of how much local disk storage might be useful. With the decreasing cost of minicomputers, it is expected that this mini-maxi-computer combination will become commonplace in the future.

Man-Job Assignment Models

A continuing sub-task of the civilian manpower exploratory development research program has been the investigation of the possibilities of using models to assist in designing organizations. This stream of work has been named Models for Organization Design and Staffing (MODS). One form of model which has emerged from this fundamental research is the static multi-attribute assignment model. Planning is underway to initiate testing of a larger (600-800 man-job combinations) blue collar population in Fiscal Year 1977. Such testing will include development of a revised computer support system influenced by the lessons learned in the Naval Ship Research and Development Center (NSRDC) tests concluded in 1975 by Moore and Sholtz [18]. Exploratory development research is continuing in parallel with these tests in the areas concerned with white collar employees and with algorithms to permit dynamic (more than one period match) assignment planning.

Mathematically, the static algorithm is a reduction of a biased-quadratic goal programming model into a distribution model. A statement of this algorithm as described in [3] is reproduced as follows:

Let

$x_{is} \equiv$ amount of individual s assigned to job i

$a_{sj} \equiv$ amount of jth attribute possessed by individual s

$r_{ij} \equiv$ amount of jth attribute desired in job i

$m_{ij} \equiv$ amount of jth attribute required in job i

$k_{ij} \equiv$ a weight indicating the importance of attribute j in job i

$c_{is} \equiv$ "cost" associated with assigning individual s to job i

$J_i \equiv$ set of all attributes j relevant to job i

The problem to be solved is as follows:

subject to the constraints

$$\sum_s x_{is} = 1 \text{ for all } i$$

$$\sum_i x_{is} = 1 \text{ for all } s$$

$$x_{is} = 0, 1 \text{ for all } i, s$$

$$0 \leq r_{ij} \leq 10$$

$$0 \leq a_{sj} \leq 10$$

$$k_{ij} \geq 10 - r_{ij}$$

$$x_{is} = 0 \text{ if } \exists\, a_{sj} < m_{ij} \text{ for } j \epsilon J_i$$

we wish to minimize $\sum_i \sum_s c_{is} x_{is}$

where $c_{is} = \sum_{j \epsilon J i} a_{sj} [a_{sj} - (2r_{ij} + k_{ij})]$.

Thus, to find the "best possible" match between a pool of personnel and a number of jobs, the inputs required are the following:

for each individual,

a measure of the amount he possesses of each attribute;

for each job,

the minimum amount of each attribute required,

the desired amount of each attribute, and

a weight indicating the importance of each attribute.

For attributes we selected a job-element system based on the task-inventory technique. An inventory of all significant tasks stated in behavioral terms is constructed from every possible source of occupational information. Personnel proficiency may then be measured as it is related to a specific task statement of job behavior. Questionnaires such as that illustrated in Figure 9 are administered to the individual workers to collect self-ratings of performance and knowledge proficiency, which are then vouchered by the first-line supervisor. Then data on job requirements for positions to be filled are collected from supervisors using the same task inventory instrument.

A simplified flow diagram of the revised computer support system is given in Figures 10 and 11. The first part of this computer support system shown in Figure 10 is concerned with data collection and reduction. The tests at NSRDC proved decisively that optical scanning was the only practical way to collect and transform the data to magnetic media. The data on both personnel and job requirements is edited and updated with any changes desired to cleanse the input. Computer files are then produced which are fed into a computer program to winnow out the minimally qualified people for each of the jobs. Two reports as shown in Figures 12 and 13 are produced to indicate (1) by job the people who

STATIC MULTI-ATTRIBUTE ASSIGNMENT MODEL
TASK INVENTORY FORM

STEP 3. Enter own qualification for each task		STEP 1. Check own job tasks	STEP 2. Enter time code
	A. READING BLUEPRINTS, MECHANICAL DRAWINGS, AND SKETCHES (Cont.)		
	6. Identify shapes, tolerances, dimensions, finishes, and tooling points from complex blueprints.		
	7. Interpret assembly drawings & layout details when no detail drawings are available.		
	8. Read and apply military specifications.		
	ADDITIONAL TASKS Add any significant tasks you have in your present job which are not listed. ------------------------------------ ------------------------------------ ------------------------------------ ------------------------------------ ------------------------------------ ------------------------------------		

Figure 9

MODELS FOR ORGANIZATION DESIGN AND STAFFING (MODS) DATA COLLECTION AND REDUCTION

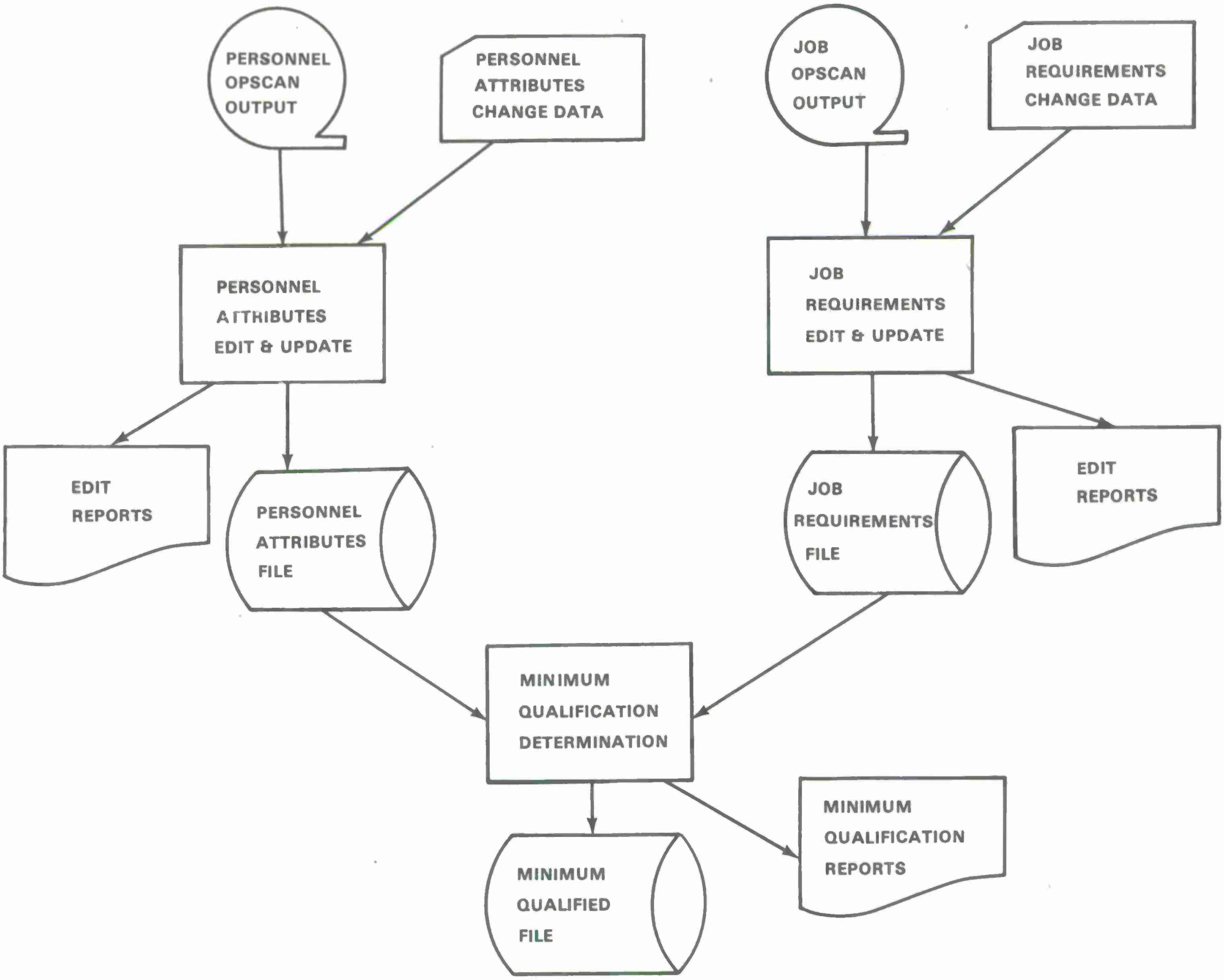


FIGURE 10

MODELS FOR ORGANIZATION DESIGN AND STAFFING (MODS)
OPTIMUM MAN-JOB MATCH

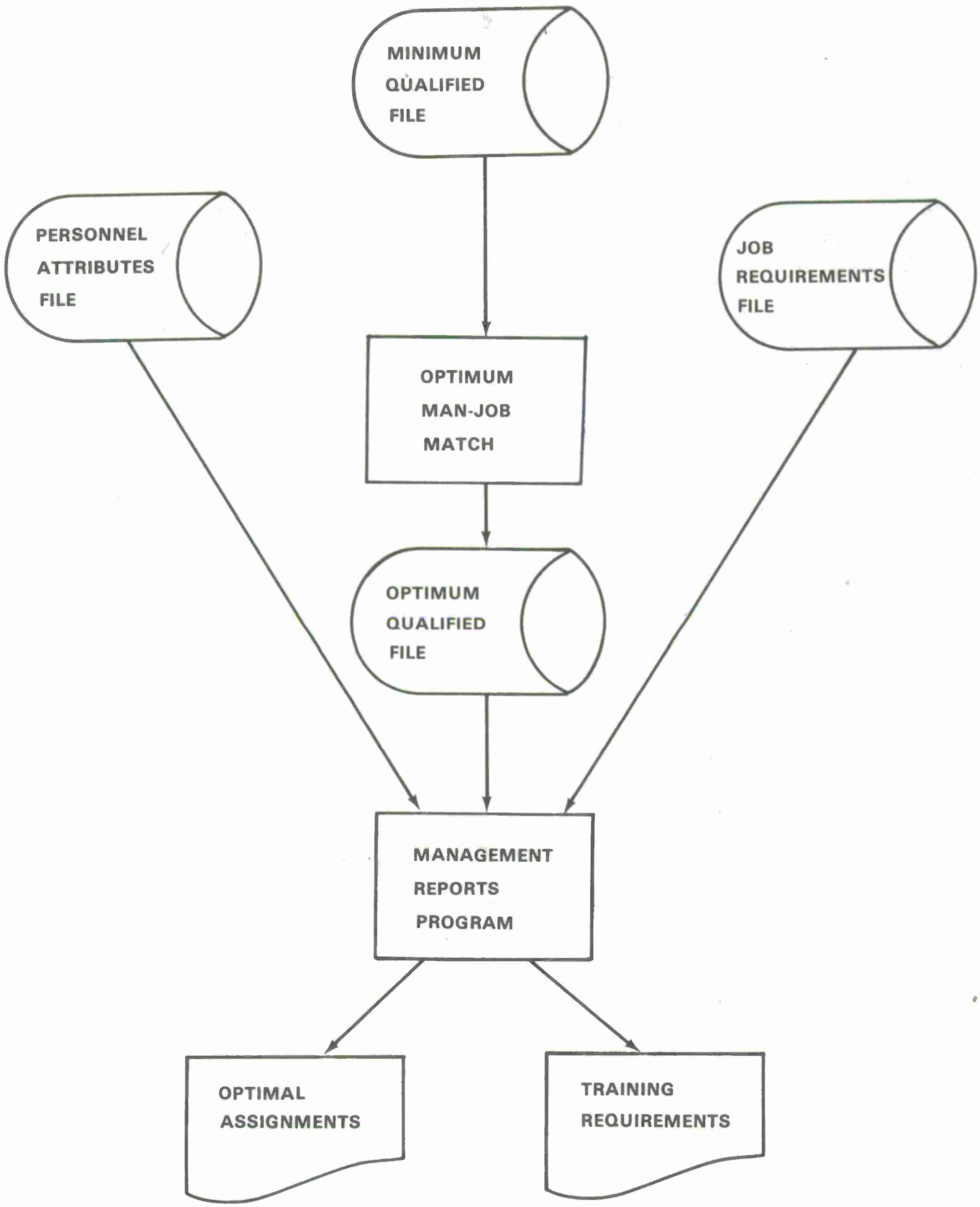


FIGURE 11

POSSIBLE MATCHES BY JOB REPORT

JOB NUM	JOB DESCRIPTION	SSN	PERSONNEL NAME
380010000	SHEETMETAL MECHANIC		
		000000001	WILLIAM FREDERICK C
		000000002	HOWE CHARLES A
		000000003	JONES JAMES A
		000000004	WILSON ROBERT P
		000000005	EDWARDS BOBBY N
		000000006	NELSON JOHN G
		000000007	SAMPS BOB A
380013000	MODEL MAKER-SHEETMETAL-SHT-PL		
		000000001	WILLIAM FREDERICK C
		000000006	NELSON JOHN G
		000000007	SAMPS BOB A
388011000	SHEET AND PLATE WORKER WELDING		
		000000001	WILLIAM FREDERICK C
		000000002	HOWE CHARLES A
		000000004	WILSON ROBERT A
		000000005	EDWARDS BOBBY N
		000000006	NELSON JOHN G
		000000007	SAMPS BOB A

Figure 12

POSSIBLE MATCHES BY PERSON REPORT

SSN	PERSONNEL NAME	JOB NUM	
000000001	WILLIAM FREDERICK C		
		380010000	SHEETMETAL MECHANIC
		380013000	MODEL MAKER-SHEETMETAL-SHT-PL
		380611000	SHEETMETAL MECHANIC
		388011000	SHEET AND PLATE WORKER WELDING
		388013000	MODEL MAKER-WELDING-SHT-PL
000000002	HOWE CHARLES A		
		380010000	SHEETMETAL MECHANIC
		380611000	SHEETMETAL MECHANIC
		388011000	SHEET AND PLATE WORKER WELDING
000000003	JONES JAMES A		
		380010000	SHEETMTAL MECHANIC
000000004	WILSON ROBERT P		
		380010000	SHEETMETAL MECHANIC
		380611000	SHEETMETAL MECHANIC
		388011000	SHEET AND PLATE WORKER WELDING

Figure 13

are minimally qualified and (2) by person thejobs for which they are qualified.

As shown in Figure 11, the computer file of minimally qualified people including the job requirements data is fed into the optimum man-job match program. This program uses the biased-quadratic algorithm to compute the "costs" of the distribution problem. Solution of the distribution problem is obtained using the solution algorithms of Glover and Klingman [12]. These results can then be printed out in two management reports. The first as shown in Figure 14 is a listing of the optimal assignments. The second as shown in Figure 15 is a training report for each individual showing the discrepancies from the goal value for each attribute. Using this report one could design a training program which seeks to correct the deficiencies which would have the greatest impact in job performance and productivity.

The chief difficulty in using the MODS static model software is the amount of work required first to develop the questionnaire and then initialize the data base. A test site at a large naval industrial facility was started and then delayed due to a large scale shift in workload for the test population. Because of this fact, emphasis in the current Fiscal Year was shifted to completion of the software and to a smaller population of white collar employees at the Naval Underwater Systems Center. Examination will also be made of the work required to install the software on a data communications network. This will help to minimize the need to find suitable computer facilities in subsequent prototype studies.

Another area which is being studied is the sensitivity of model results to the weights chosen for each of the attributes. This study, underway by Abraham [1] is using a single numerical example to test model metrics suggested by Charnes, Cooper, Klingman, and Niehaus [4], by Srinivasan and Thompson [23], and by Steuer and Wallace [24].

OPTIMAL ASSIGNMENTS REPORT

JOB NUM	JOB DESCRIPTION	PERSONNEL SSN	NAME
380010001	SHEETMETAL MECHANIC	000000003	JONES JAMES A
380013001	MODEL MAKER-SHEETMETAL-SHT-PL	000000007	SAMPS BOB A
380611001	SHEETMETAL MECHANIC	000000005	EDWARDS BOBBY N
380611002	SHEETMETAL MECHANIC	000000004	WILSON ROBERT P
380611003	SHEETMETAL MECHANIC	000000002	HOWE CHARELS A
388011001	SHEET AND PLATE WORKER WELDING	000000006	NELSON JOHN G
388013001	MODEL MAKER-WELDING-SHT-PL	000000001	WILLIAM FREDERICK C

Figure 14

TRAINING REQUIREMENTS FOR THE OPTIMAL SOLUTION REPORT

SAM WAS ASSIGNED TO MODEL MAKER-SHEETMETAL-SHT-PL (380013001)

ATTR NO	SCORE	REQUIREMENT	ATTR NO	SCORE	REQUIREMENT	ATTR NO	SCORE	REQUIREMENT	ATTR NO	SCORE	REQUIREMENT
4	8	0	8	2	8	9	8	0	10	6	8
11	6	8	12	4	8	13	4	8	14	4	8
15	6	0	16	8	0	17	6	0	18	6	0
19	6	0	37	8	0	38	8				
43	8	0	44	8	0						
47	6	8	48	6	8						
51	8	0	52	8							
55	6	8	56								
79	8	0	80								
98	6	8	107								
110	2	6									
128	6	0									
132	6	8									
136	8	0									
168	2	0									

Figure 15

In the SAMPS project one of the potential uses of the static version of MODS would be the further evaluation of the results obtained from the aggregate recruiting requirements model. In this case, the task analysis would center upon those jobs where hiring or firing is indicated in the aggregate model. The objective would be to see how many of the jobs in areas where additional personnel are required might be filled through transfer and training of people whose present jobs are to be abolished. This would help to minimize the turbulence caused by layoffs and reductions-in-force. A similar kind of study will be made to evaluate possible military-civilian tradeoffs to ensure a proper balance of sea-shore rotation.

Other Considerations

By its very nature the SAMPS research interacts with a wide variety of scientific disciplines, information systems and management practices. The research is directed both toward the need for answers to fundamental questions as well as ahead to the operational uses of the models. Also, technology being developed by others may be substituted if it appears prudent to do so. As in any environment of this nature, a deliberate attempt is being made to define sub-tasks and complete them with as few changes as possible. Any larger scale changes are saved for inclusion in the next version.

In order to provide interim capabilities and some stability in the software development and applications testing, the computer support system is being programmed first for the batch environment on a Navy UNIVAC 1108. This batch system is then being converted to the data communications network. This network system will then be changed to a conversational system using the lessons learned from the prototypes underway at NARF, San Diego and NUSC, Newport. This completed system then will be a research tool for developing more thoroughgoing versions of the manpower and personnel planning systems under study.

An area which is to receive increased attention, once the batch network capability is in place, is the planning for equal employment opportunities. By then, the first version of the headquarters EEO models will have been used to develop the FY 1977 Affirmative Action Plan for the Navy. Also, the new information support arrangements consistent with this Affirmative Action Plan are expected to be operational at that time. The changes to the SAMPS software to accomodate EEO planning are mainly the addition of another set of equations in the model matrix generator. The conversational form of the EEO models will not be included in SAMPS until the conversational network system is developed.

A population of civilian ungraded and military enlisted personnel will be among the next prototypes of the man-job assignment models. Since the critical decisions on military-civilian planning at the local level center around task assignments, development of such a task list appears to be a way to initiate investigation of this area. This will be done by developing and administering the same job-element questionnaire to a military-civilian population accomplishing a closely related function such as communications or missile tracking. Preliminary investigations are now underway to select a suitable prototype population.

Other considerations which extend beyond the scope of the SAMPS project include (a) the relationship of headquarters manpower planning to the field installation planning and (b) macro military-civilian planning. With a careful design these other manpower resource considerations should be able to be included directly as part of the system. In the case of the headquarters-field civilian planning relationship, the combination of EEO planning with the SAMPS should provide a mechanism to improve skills planning at both levels. Since a common job-category coding system is being employed, better information developed at either level will be available to aid in this improvement.

The manpower requirements data for such a system could be provided either from local workload planning systems or from central systems using the methodology and standards developed by SHORESTAMPS. Also, the SAMPS network capabilities would be extended as that access to relevant planning data could be easily and quickly made available to the management level concerned. Such access would have to include the necessary management controls so that the resulting decisions would be of benefit to both the management levels concerned. This type of reasoning could be extended further to include macro military-civilian tradeoff considerations. The result would be an integrated military-civilian manpower planning system providing timely and meaningful management information. Considerable discussion and research remains before such a system could be brought into being.

In conclusion, the SAMPS project is aimed at providing benefits to the Navy in terms of its management, employees and information technology support base. For the management, it should allow a direct evaluation of the costs of changing skill mixes and thus provide better manpower utilization at the local level. For the employees SAMPS should provide for better careers and equal employment opportunities based upon a planned approach to the desires of the individuals. Both will be accomplished through the development of a management system oriented toward the information technology probable in the 1980's.

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This report describes the U. S. Navy Shore Activity Manpower Planning System (SAMPS) advanced development research project. This effort is aimed at large-scale feasibility tests of manpower models for large Naval installations. These local planning systems are integrated with Navy-wide information systems on a data-communications network accessible via mini-computers. This includes both intake requirements planning models and man-job task analysis models as well as workload forecasting systems which are integrated with the manpower planning process. In addition to the system design considerations, experience from preliminary tests is discussed.